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Project Director: Jeffrey Forgeng (jforgeng@higgins.org)

Institution: John Woodman Higgins Armory Museum, Inc.

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The Virtual Joust

Jeffrey L. Forgeng, Project Director
Higgins Armory Museum
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Contextual Background: Closing the Armory and finding the collection a permanent home

The Virtual Joust project was executed at a time of existential crisis for the Higgins Armory Museum. While many details of the project can be understood independent of the context, a full understanding of the course and outcomes of the project calls for contextualization within the major strategic crisis at play in the museum during the period of the project's execution. This first section provides that background, while the following section picks up the more focused narrative of the Virtual Joust project itself.

When the Higgins Armory was awarded the Virtual Joust grant in August 2010, the museum was at the decisive moment of its 80-year history. The museum's director had resigned the previous month, the culminating act of a multiyear period of institutional dysfunction. Indeed the decision to apply for the digital humanities grant was in many ways driven by that dysfunction: as project director, I had serious doubts about the institution's capacity to deliver on this rather ambitious proposal, but felt obliged to pursue the grant due to the museum's internal political situation.

The change in leadership solved the political situation, but the underlying capacity issues remained. Over the following months, the interim director focused on sorting through the museum's accounts to determine exactly where the institution stood financially. By fall 2010, it had been determined that the museum's existing business model was unsustainable, based as it was on a budgetary shortfall of nearly half a million dollars on a $1.5 million budget.

The underlying issue was structural. The rule of thumb for museum funding suggests a threefold division about equally divided between earned income, endowment income, and contributed income. The Higgins is 70% dependent on earned income, while the institution's meager endowment cannot sustainably provide even as much as 10% of the budget.

This underlying structural inadequacy had been in place since the museum opened its doors in 1931. During John Woodman Higgins's lifetime, the institution was personally supported by its founder and namesake. After Higgins's death in 1961, the museum entered a period of decline that culminated in a proposal in 1979 to merge the collection with the Worcester Art Museum. The proposal was accepted by the museum's Trustees, but rejected by its Incorporators after a vigorous lobbying campaign by Higgins's surviving children, who promised to make up any operating deficits out of their own pockets for the following decade. When family funding phased out at the beginning of the 1990s, the museum remained relatively stable for a time thanks to the robust stock market of that decade, but the economic downturns of 2001 and 2008 brought the institution back to the harsh underlying reality.

With only about $2 million remaining in the endowment by 2010, there was insufficient cushioning to support an institutional turnaround: the Higgins Armory would have to close, and needed to find a sustainable home for the Higgins collection quickly, or face the prospect of breaking up North America's second-largest collection of arms and armor.

The following two and a half years were dominated by the need to find a home for the collection while keeping the institution afloat in the short term. Much of late 2010 to 2011 focused on the development of new exhibits and programming to improve visitation, while trimming expenses wherever possible, to give the museum the maximum possible time to secure a future for the collection. Major exhibit initiatives included the installation of two new permanent exhibits, a temporary exhibit (which incorporated the Virtual Joust), and a half-million dollar hands-on exhibit called Castle Quest. Meanwhile, budgetary cutbacks included the reduction of curatorial full-time staff from 3 to 2 positions.

During 2011 discussions were initiated with multiple potential partner institutions. At the same time, the museum was laying the groundwork for a merger, particularly by bringing the museum's Trustees up to speed—a formidable challenge for an institution that had a history of concealing its real situation from its own Trustees. By the end of 2011, the museum had largely settled on transferring its collection to the Worcester Art Museum (WAM), though there remained considerable skepticism among constituents in both institutions about the viability of this partnership.

2012 was dominated by the process of negotiating a preliminary agreement for the approval of the Boards of both the Higgins and WAM. At the same time, the Higgins initiated a massive project of collections refinement. John Woodman Higgins had founded his Armory as a museum of metalcraft—the focus on armor had been instituted during the 1970s—and his vision of the museum's Great Hall was a space stuffed with arms and armor in the fashion of a Gothic-Revival baronial hall. As a result, much of Higgins's collection was no longer relevant to the museum's mission, or was "window-dressing" that added to the museum's atmosphere without enhancing the real content of the collection. Since the early 2000s, a project of collections refinement had been deaccessioning about 50 objects a year, but as of 2011 the museum still had about 4500 objects in its care, while the "core collection"—the part of the collection that truly merited museum stewardship—was estimated at about 2000. The non-core component of the collection needed to be deaccessed quickly in order to make the Higgins an attractive acquisition for a partner institution, roughly a 25-fold increase of the pace of an already vigorous deaccessioning program. This process is still in full swing, and must be completed by the time the museum closes its doors at the end of 2012.

At the time of this present report, the Higgins and WAM are negotiating the specifics of the integration of the Higgins collection into WAM, while building support among relevant stakeholders for the dramatic transition and raising the money to make it possible.

Naturally, all of these factors impacted substantially on the Virtual Joust project. Not only was it executed within an environment of crippling budgetary and existential crisis, but the museum's curator—the only person capable of directing the project—was also a key player in addressing the crisis and building a long-term solution. The challenge of juggling these various needs can hardly be overestimated.

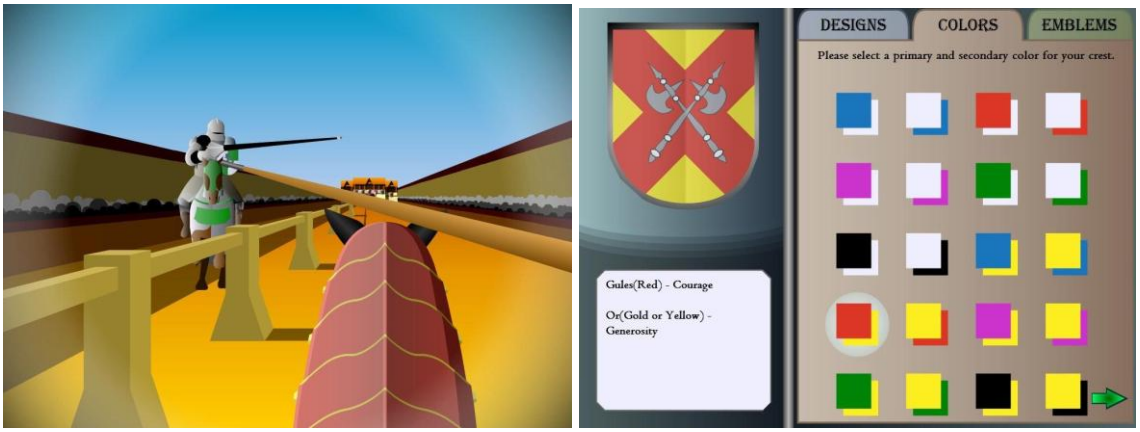
The Virtual Joust Project

To some degree, the course and outcomes of the Virtual Joust project cannot really be extrapolated to institutions that aren't in a comparable state of crisis. On the other hand, the fact that the project was successfully completed in almost every aspect of the proposed work, in spite of the circumstances, is testament to what can be achieved when resources are deployed strategically over a long period; and the details of the course and outcomes are certainly relevant to other institutions in an environment where digital content is increasingly expected of museums by both funders and patrons.

Given the organizational dysfunction at the time of application, it is hardly surprising that the decision to apply for the Virtual Joust project was made for the wrong reasons; at the same time, once the commitment had been made to implement the project, it was possible retroactively to integrate the project with the institution's other strategic needs.

At the grant application stage, one of the consultants I interviewed for the Environmental Scan asked whether the museum was pursuing this digital project with real strategic purpose, or whether we were simply proposing the project *ad hoc* because it seemed like the thing to do at the time. I steered away from answering, because I knew that it was the latter, and because I shared the consultant's skepticism about initiatives that lack a clear strategic intent. This project was driven by opportunity and politics rather than by a clear picture of the institution's long-term direction. On the other hand, opportunity and politics always play a role in institutional decisionmaking, and the Virtual Joust successfully made a virtue of necessity by finding ways to align itself with the broader strategic context.

The Virtual Joust had begun with an Interactive Qualifying Project (IQP) by a team of students from Worcester Polytechnic Institute. The IQP is an interdisciplinary project done by WPI students in their third year, looking at technology in its human context. One version of the IQP focuses on the history of technology, and under this rubric students from WPI have been doing projects at the Higgins Armory for over three decades, looking at the artifacts in the Higgins collection in their historical context and finding ways to interpret this context for museum visitors. In 2008-9 a team of students developed a pilot version of a jousting game, in which visitors used a Wiimote to interact with a Flash-based game that was presented via a digital projector.



Gameplay and Heraldry Selector from the Pilot Virtual Joust

Due to technical limitations, this game was not sustainable as a standing installation, but its pilot run was popular with visitors. The game also incorporated a number of creative historical features: players selected their own heraldry, which was incorporated procedurally into the game visuals, and received their results as a scorecard modeled on surviving historical examples.

The successful completion of the project prompted the museum to seek an NEH Digital Humanities grant in 2009 in order to develop a sustainable version for permanent installation, and the existence of a proof-of-concept version presumably played a significant role in securing the grant. In spite of my doubts about the museum's capacity to deliver and the usefulness of the plan—particularly the sustainability of such an installation in an institution that had no dedicated IT staff—I felt it would be politically inadvisable for me to resist the idea given the museum's fraught leadership situation at the time.

The player apparatus for the Pilot Virtual Joust, and a view of the gameplay screen.

Once the grant was awarded, it would have been equally difficult to turn down the money, but happily the change in leadership made it possible to redirect the project in ways that would better align the project with the museum's needs and capacity. The museum reorganized its temporary exhibition schedule to create a temporary exhibit around the Virtual Joust, opening in October 2011, entitled *Extreme Sport: Jousting Then and Now*; in principle, the Virtual Joust would

migrate to the permanent galleries after the temporary exhibit closed. Since a temporary exhibition needed to be produced in any case, this arrangement allowed the work of the Virtual Joust project to integrate with that of the temporary exhibit—a huge help to the curator who would be responsible for both. It also deferred the work of reinstalling content in the permanent galleries, as well as the issue of long-term technical sustainability. There was much to be said for trying out this groundbreaking technology on a temporary basis before committing to it in a permanent installation.

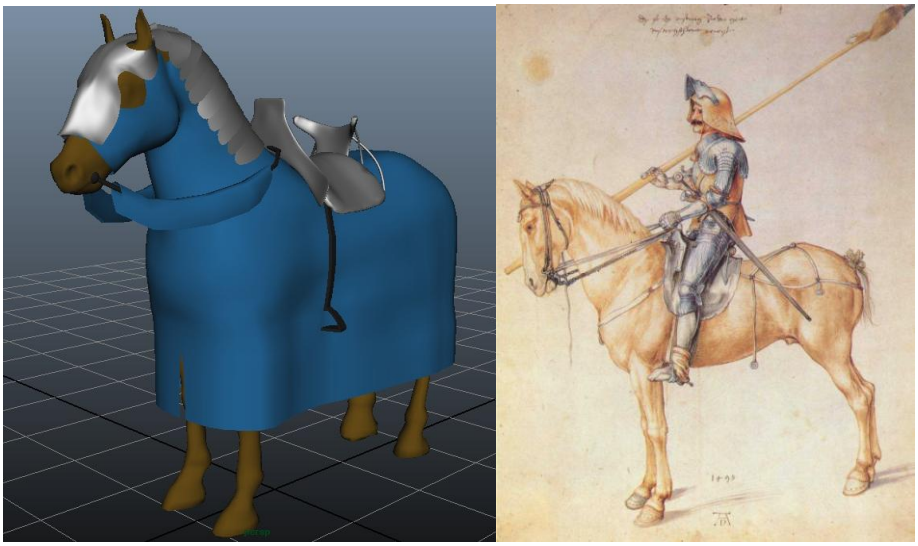
The project proposal had recruited two consulting professors from WPI's Interactive Media and Game Development program: Prof. Brian Moriarty, would supervise technical aspects of the work as well as providing general assistance in a variety of areas of game development, and Prof. Britt Snyder would oversee artistic elements of the game. Through these faculty we recruited a team of undergraduates to execute the bulk of the work: Chris Chung and Alfreda Smith to generate the game art, and Cordell Zebrose to do the programming. The team met weekly at WPI beginning in fall 2010 to move the project forward. At each stage, the advisors and I would review the status of the students' work and recommend next steps. Major components were divided between the modelers: Smith created the jousting arena and horse, Chung created the knight and his equipment.

The initial stage of developing the game assets—particularly the 3-D models just mentioned—was one of the most challenging and interesting parts of the process. Normally, a curator or historian has the luxury of working around gaps in their knowledge, but one can't have blank spots in an immersive game. The student designers needed details: how long should the jousting run be; how tall should the horse be; what should the armor look like?

Closeup of the jousting knight.

My ability to deliver answers was hugely helped by resources I had already been developing during my years as a curator. Since 2006 I had been compiling a database of potentially useful images (over 3000 jpgs), from which I was able to assemble substantial folders of reference

images to assist the designers in their work. In 2005 I had commissioned a suit of 15th-century style armor, and Chung was able to study and photograph the suit components in detail in order to design the jousting knight. My scholarly work in translating medieval Iberian jousting treatises likewise proved hugely helpful in providing other data required by the design team.



Preliminary model of the horse. The horse itself (largely obscured by the cloth caparison) was based heavily on Albrecht Dürer's watercolor study for "Knight, Death, and the Devil." The saddle was based on a reproduction by Jeffrey Hedgecock of the Tournament of the Phoenix.

Once the horse and knight models were complete, they were animated by an outside professional specialist, on Prof. Snyder's recommendation. Getting 3-D models to move convincingly is a subtle, time-consuming, and challenging art, and extremely important to the overall feel of the game, and Snyder felt it would be beyond the capacity of students to execute it satisfactorily. The animations were based on footage of some of the world's most accomplished modern jousters. I had generated this footage using WPI equipment as part of a multiyear collaboration with the Tournament of the Phoenix in San Diego, one of the world's premiere historical jousts. At the time I did the filming in 2008, I didn't know all the purposes to which it might be put, but was certain that having good footage of jousting was certain to prove useful for an armor museum. Our long-term collaboration with the Tournament of the Phoenix proved useful in many other ways as well: the tournament managers provided additional helpful visuals for the modelers (such as jousting saddles), and jousters from the Tournament were interviewed for relevant insights based on their personal experience of the sport.

The horse, showing the personalized heraldry generated in-game. From this angle the audience can be seen to be 2-dimensional cutouts.

The project proposal had envisioned an online component for the Virtual Joust, but based on the recommendations of the development team, it was decided to defer this idea: the team felt that this was too ambitious to add on top of the development of the game itself. This decision proved wise: managing the development of the game was a sufficient challenge, and in the end it became possible to execute an online version of the game quite economically and effectively once the game itself was complete. In the mean time, the team created a Facebook site for the project, posting some early samples of game assets, but in spite of some early interest on the site, it never gained much momentum, probably because the museum lacked the capacity to push content to the site on a regular basis.

One reason for deferring the online component was the conviction on the part of the development team that the esthetics of the actual game needed to be well developed. Prof. Snyder felt that the level of expectations in the current environment of high-quality visuals in contemporary computer games made it essential to replace the cartoonish, 2-dimensional visuals of the pilot version with visual content of high production values. The artistic team delivered successfully on this goal, and although most visitors may not actively notice the level of detail embedded in the game graphics, its presence contributes to the power of the experience (one might compare the role of lighting in cinema or museum displays—it is rarely noticed by non-specialists, but it plays a crucial if subliminal role in delivering emotional impact).

The "écranché" jousting shield, showing some of the level of detail embedded in the models.

The broad outlines of the gameflow had largely been worked out in the Virtual Joust IQP; based on this, Prof. Moriarty drafted a gameflow document that detailed the game content and dialogue, which I revised for historical authenticity. At every level, decisions were taken that helped integrate the Virtual Joust with the broader context of the Higgins Armory. I consulted with the museum's Director of Programming to decide whether to connect the Virtual Joust directly to jousting armor in the museum's collection. One option would be to set the joust in the late 1500s—the period of most of our jousting armor, but well after the medieval period that our visitors were certain to expect. Alternatively, the joust could have been tied to our jousting suit of circa 1500, made for the *deutsches Gestech*, a highly specialized version of the joust using distinctive gear that covered only the upper body.

The museum's Gestech armor (HAM 2580).

In the end, we decided to present a fifteenth-century "joust of war," in which contestants used battlefield armor with a few reinforcing plates for added protection. This option was less closely tied to specific objects in the museum's collection, but it connected to visitors' interest in a medieval experience, and allowed us to integrate the Virtual Joust with the content of our adjacent Castle Quest interactive area, which is set in the environment of a fifteenth-century castle.

The armored jouster, based on a reproduction suit modeled on fifteenth-century examples in the Kunsthistoriches Museum, Vienna.

In some cases, historical accuracy had to give way to practical constraints. The usual venue for a joust would have been an open field or a town square, but these environments would have been

hugely complex to model. As a result, the joust was set in a less typical setting—a purpose-built arena, based in part on images from Réné d'Anjou's fifteenth-century treatise on the tournament, and in part on iconographic evidence from the early 1600s. Another compromise with historical accuracy was the lack of servants on the jousting field: each one of the jousters would have been attended by at least one servant, and probably several. Again, the models for these would have been very expensive to produce—more so than the knights themselves, who were conveniently encased in easy-to-model steel. Strategic redeployment of existing assets was used to help fill out the jousting field a bit: the model of the lance was used to create racks of lances on each side of the field, and the armorer character from Castle Quest was also inserted into the scene—far enough back that his 2-D design would not be too obtrusive.

Early screenshot of the jousting arena model.

One of the most formidable, and least anticipated, challenges of the project was the introductory sequence. Players needed some kind of introduction that set the scene and laid out the parameters of the game. Computer games typically achieve this through "cutscene" footage in which the players watch a scripted animation that sets the scene, with occasional input from the player to establish a character name and other parameters. However, this kind of animation, requiring at least one fully animated human character, would have been prohibitively expensive compared to the animation of the game itself, which achieves its effect with a very limited repertoire of animated routines executed by fully armored models—obviously much simpler to animate than a human face.

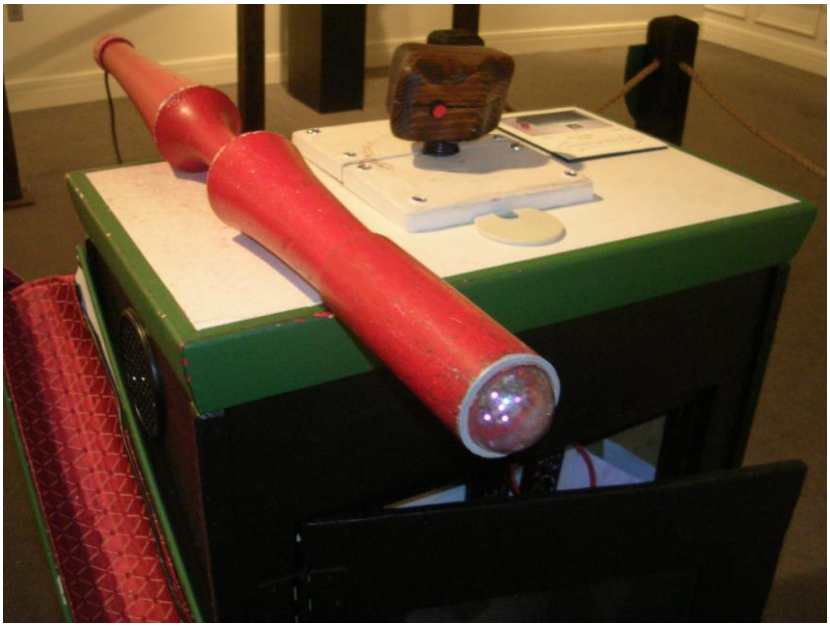
Here again, preexisting contacts nurtured over time allowed a powerful introduction to be created with very limited resources—thanks to a great deal of volunteer help. Wolfe Argent, the museum's volunteer demonstrators who recreate military life of the mid-1400s, provided personnel, costume, and equipment; my own neighbors provided a shooting location (complete with horses); and Higgins gallery interpreter Ashlie Jensen portrayed maidservant Eleanor Grey, a character from the Castle Quest exhibit who was ideally suited to orient visitors to the game

(this character was also used to narrate the game, and reappears at the end to congratulate or console the player, depending on the outcome of the contest).

Ashlie Jensen as Eleanor Grey, with servants and equipment provided by Wolfe Argent, setting and horse provided by Kristin and Neal Mitchell

On the technical side, the successful outcome of the project rested on outstanding work by Cordell Zebrose and Prof. Brian Moriarty, both of whom went well above and beyond in their contributions to the project, showing considerable technical mastery as well as ingenuity in managing both software and hardware. Zebrose programmed the game using the Unity game-design software. Moriarty repeatedly stepped up to fill gaps: in addition to providing general technical consultation and creating the specialized hardware for the game, he served as cameraman and sound designer, and the power of the game was considerably enhanced by his creative use of sound to enhance the mood of the various scenes.

The operator input devices (lance-stub and joystick) were especially challenging to design, and the initial build of the lance sensor system proved unworkable: the motion sensor that was initially envisioned for the lance had to be mounted horizontally, but the only convenient place to mount it on the lance-stub was vertically, at the end. In the end the lance sensor used a "reverse" Wiimote system, with the Wii permanently mounted above the game screen and the infrared emitters embedded in the end of the lance-stub (protected by the plastic covering from a snowglobe!). A motion sensor was mounted in the "reins," a wooden joystick manipulated by the player's left hand to initiate each run and guide the horse.



The Virtual Joust apparatus, viewed from opposite the player's position. Infrared emitters are protected by a plastic bubble at the end of the lance-stub. The left hand controls the "reins" joystick, which includes a red button for a "Select" input. At left is a holster for storing the lance between games. The computer apparatus is kept inside the kiosk.

The Virtual Joust in action. The Wiimote is mounted above the flatscreen; speakers are mounted to either side, and the woofer unit is on the floor below.

Game Context

Second room of the exhibition in the final stages of preparation. The "heft-a-lance" installation is on the left, the Virtual Joust on the right

The Virtual Joust went live at the exhibit opening of *Extreme Sport: Jousting Then and Now* in October 2011. *Extreme Sport* features extremely rare examples of arms and armor created for the tournament—such objects were never created in the same quantity as military arms and armor, and survivals are not common. Many of these objects have never been on display before. The museum's exhibit development team crafted a powerful visitor experience around these objects. A separate grant from MassHumanities supported a series of visitor interactives to complement the Virtual Joust. There is a short and engaging miniquiz interactive that gives the visitor "hints" in the form of primary-source material; a hands-on reproduction lance that allows visitors to feel the lance and experience first-hand how the lance/handguard/lance-rest/stop/breastplate system actually works (something almost impossible to understand from the artifacts or from visual representations); and for those who are interested in digging deeper into the story of tournaments there is an oversize illustrated flip-book. In addition, a continuous-loop DVD, filmed at the Tournament of the Phoenix and sponsored by the museum, offers visitors a chance to see live jousting in action, as well as interviews with modern practitioners of the sport. Overall, the variety of media seeks to capture the broadest possible range of visitor profiles and learning styles, and offer multiple points of access and perspective on the exhibition theme.

The timeliness of the exhibit surprised even the museum: modern sport jousting is starting to find its way into public awareness, reflected and furthered by the fact that both National Geographic and the History Channel produced programs on the subject at about the time the exhibit opened (*Knights of Mayhem* and *Full-Metal Jousting* respectively). The exhibit specifically emphasizes

the connection between past and present, juxtaposing medieval with modern-day jousting (with such elements as a striking display of lance-shards from the Tournament of the Phoenix), and conveying the role of the tournament as the ultimate action sport of its day—a concept already familiar to many visitors thanks to its technically ahistorical yet emotionally effective representation in the 2001 film *A Knight's Tale*.

The Virtual Joust's popularity with visitors has been entirely as predicted. As can be seen in one of the previous photographs, there is always a line of people—especially, but not exclusively, young ones—eager to try their hand. Those who are waiting their turn enjoy watching the game, and in general, the game appears to be played very socially, which is a highly desirable outcome in a museum environment, where social learning has been found to enhance the museum experience for visitors.

Less expected was its initial robustness: the installation is technically complex, and many of us on staff were braced for an immediate barrage of technical issues, bugs, breakages, and the like. To our surprise, the installation initially required very little maintenance: the roped stanchions surrounding the playing area required more attention than the electronics.

However, it would be unrealistic to expect that technology this complex could run indefinitely without problems. After running fairly smoothly for the first 6-8 months or so, by summer 2012 issues were beginning to crop up. At first, most of these related to wear and tear on the hardware. The first major issue cropped up when the "reins" interface had to be repaired in June due to wear on the wiring. The replacement hardware was fully functional, but the program continued to malfunction after the repair. Eventually the problem was identified as relating to the interface between the software and hardware: replacing the reins had led to a change of port assignment in the hardware, making it necessary to change a "3" to a "4" in the code, and the issue was documented in case it came up again.

The resolution of these issues has been complicated by the project's dependence on external personnel. WPI undergraduate Zebrose, who designed the software, is the only person

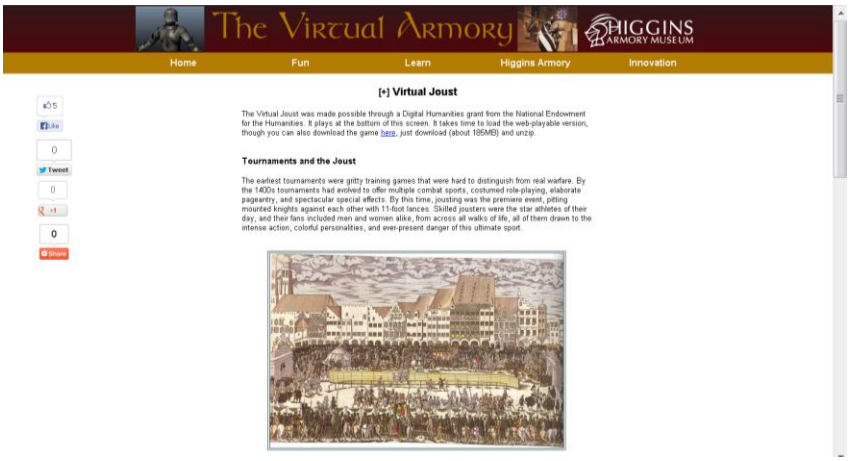
sufficiently familiar with it to be able to evaluate software problems; Prof. Moriarty, who created the hardware, is essential to evaluating hardware issues. Resolution of problems in the Virtual Joust is subject to the availability of these two consultants. Prof. Moriarty generously does his work for us pro bono, but the museum has, appropriately, set up a consultancy structure for Zebrose—something that in retrospect should have been anticipated in the planning of the project.

Virtual Joust Online

Because the finalized hardware and software came in substantially under budget, we were ultimately able to develop the proposed online component. In retrospect, this sequencing of work was actually preferable to our original plan, since the online content could be developed in specific relation to the finished game. As it happens, Unity includes a feature that allows a web-playable version of the game to be generated by the program, though adjustments had to be made to allow for keyboard controls.

Nonetheless, the web component proved challenging to implement due to administrative factors. The WPI student hired to develop a web-playable version of the Virtual Joust proved a serious management challenge. In part this was due to mismatched understanding of the scope of work: the museum believed he was being hired chiefly to develop a web-playable version of the Virtual Joust, while the student believed that he was only being hired to create the website within which the Virtual Joust would be housed. Again, in retrospect, it was unrealistic to imagine that anyone but Zebrose would be able to adapt the Virtual Joust for the web.

The issues with our web developer to some degree reflect the fact that he was the only applicant to apply for the position, due in large measure to the museum's lack of capacity to recruit more vigorously for a better candidate pool. In the end, Zebrose was engaged to generate the web version of the game, and the web developer was fired from the project. A recent WPI graduate, Nathan Krach, was hired to complete the website. Krach was recruited through known WPI networks, and since the museum knew it was hiring a web designer rather than a Unity programmer, it was much easier to find a satisfactory candidate. Krach's work on the project was creative and enthusiastic. The site can be seen at http://users.wpi.edu/~virtualarmory.



The Virtual Joust page. Visitors scroll down to reach the game screen—historical content here provides context as well as covering the loadtime for the game.

The online game can be accessed at users.wpi.edu/~virtualarmory/virtualjoust.html. This URL also includes a downloadable zip file of the game. Selected game assets, as well as the full sourcecode version of the game, can be accessed at users.wpi.edu/~virtualarmory/innovationvirtualjoust.html.

As with the onsite version of the game, we felt that the impact of the game was best served by embedding it in an environment that allowed multifaceted exploration of the arms and armor context. The original plan had been to develop a joust-specific site that would essentially translate the content of *Extreme Sport* into web format. However, by the time this work was beginning in summer 2012, the museum lacked staff time to support such an undertaking. Instead, context was provided by assembling highlights from over a decade's worth of WPI student projects into a "Virtual Armory" website, whose mainpage is at users.wpi.edu/~virtualarmory/index.html. The site includes interactives, videos, a virtual tour of museum highlights, and a complete database of the Higgins Armory collection.

Evaluation and Dissemination

In September 2012 the museum engaged Jan Crocker Museum Associates to develop an evaluation process that looks at the Virtual Joust within the ecology of its exhibit, to see what outcomes the installation achieves in relation to the exhibit's purposes and in relation to the other exhibit components. By late October, when the evaluation instrument was finished and staff had been trained to implement it, the touchscreen interactive in the exhibit (a miniquiz separate from the Virtual Joust but designed to complement it) had become non-functional. After many months exploring possible avenues to repair the interactive, the museum has been forced to abandon it, and will implement a revised version of the evaluation instrument that leaves out the touchscreen interactive. This is extremely regrettable, since we have hypothesized that the Virtual Joust achieves its optimal outcomes when supported by a variety of other content in different media, and it would be valuable to learn what role the different interactives play in the exhibit. But in the end, a museum without any IT staff has limited capacity to address technological issues when

they arise, particularly when the institution faces pressing existential problems that need to be solved in a tight timeframe.

In the mean time, the museum's staff have been working to complete the dissemination stages of the Virtual Joust project. Devon Kurtz, the museum's director of education, and project director Jeffrey Forgeng offered a joint presentation on the Virtual Joust and its context at the New England Museum Association meeting on Nov. 9, 2012. The presentation, entitled "Cats and Dogs Living Together: Exhibit Design as a Collaboration between Educators and Curators," was extremely well attended (standing room only), and was so well received that Kurtz and Forgeng were asked to turn the presentation into an article [*NEMA News. The Quarterly Journal of the New England Museum Association* 36:2 (Winter 2013). 8–9, 19]. The session was also proposed for the American Alliance of Museums meeting in Baltimore in May 2013, but was not selected for presentation.

Outcomes and Conclusions

In spite of all the challenges, the Virtual Joust has been a remarkable success. The game is extremely popular with visitors, and has been praised by specialist arms and armor curators. Plans are in discussion for importing the game into the installation of Higgins collection highlights at the Worcester Art Museum, opening in 2014 (although I doubt that any thought has yet been given to the game's technical sustainability, given its dependence on two technical consultants of whom one may already have graduated). The process has also been an outstanding opportunity to bring into focus our knowledge about jousting and the material culture associated with it. An unanticipated outcome of the process is the development of the models themselves, which have considerable potential as long-term digital assets for use with the Higgins collection or by others—for example, the modeled armor could become a resource for other applications that teach about the design of medieval armor.

Perhaps the greatest weakness in the outcomes is the museum's inability to promote the Virtual Joust to its full effect—paralleling the institution's lack of capacity to promote itself to gain the visibility it needed to become financially viable. This brings us back to the structural level: the institution's structural situation, particularly its anemic endowment, hobbles every aspect of its operation. Regardless of how hard its staff have tried to compensate—and the Higgins has consumed the energies of countless museum professionals over the years—it is impossible to make up for a shortfall on such a scale.

That said, tight circumstances at the Higgins have stimulated intensive creativity and a high ratio of output to input, and many lessons from the Virtual Joust project are pertinent to other institutions:

Keep focus and find opportunities to synergize. For a small museum, focusing on areas that are mission-critical and that resonate with the public is essential, and the more these areas can be integrated with each other, the better. Given the need for a rotating cycle of temporary exhibits, it

made sense for the Higgins to select topics that resonate with the public and that have the potential for further uses down the road—based on these criteria, jousting was an obvious choice for an exhibit theme. Focusing curatorial scholarship on historical sources relating to the joust has also helped build the institution's profile in the field while laying groundwork that helped make the Virtual Joust possible.

Build long-term resources in key areas. Our curatorial database of armor-related images was time-consuming to create in its early stages, but ultimately saved time and greatly enhanced outcomes in multiple projects, including the Virtual Joust, *Extreme Sport*, and Castle Quest. Similar benefits accrued from WPI student projects that served as content for the Virtual Armory, and from footage generated at the Tournament of the Phoenix.

Build strategic partnerships. This project shows what an underresourced institution can achieve by having a well-selected network of partners in key areas of strategic importance. The museum's partnership with WPI has given it access to otherwise unattainable technical resources, including both hardware and personnel. Partnerships with volunteer groups like Wolfe Argent and with organizations like the Tournament of the Phoenix also proved crucial to making the Virtual Joust possible.

Some lessons from the Virtual Joust were learned the hard way:

Use technology appropriate to the institution's size. So far, this project has miraculously dodged the bullet of technological overreach. Hopefully the Virtual Joust will remain functional through closure at the end of the year, but in Fall 2012 one of the *Extreme Sport* interactives failed, and in Spring 2013 another touchscreen interactive failed in the permanent galleries. Both of these failures probably stem from hardware issues that would be eminently solvable if we had an IT specialist on staff, but given our inability to solve even minor technical issues, the Virtual Joust was well beyond our appropriate technology level.

Provide for technological sustainability. I like to think of myself as fairly savvy for a non-specialist in managing technologic resources, but even I totally failed to foresee the project's dependence on two human beings for upkeep. This may in part reflect the number of major initiatives on my plate at the time, leaving less mental space to think through the long-term details. But it certainly underscores the need for institutions to think about these issues carefully ahead of time, and to write sustainability into their plans from the outset.

Make sure the foundations are stable before building too high. The closure of the Higgins comes as no surprise to people who have been paying attention to the museum's bottom line. Both senior staff and a few trustees have seen this problem coming for years; I myself had come to the conclusion that we would need to close as of summer 2008. In scrambling to live up to its ambitious promises on the Virtual Joust, the museum has had to divert curatorial time away from

fundamental questions of collections stewardship at a moment when curatorial expertise was most needed to preserve what could be saved of the Higgins legacy. While the Virtual Joust may have enhanced visitation to some degree, it is doubtful whether its impact has been proportional to the cost in staff time, compared to other less labor-intensive initiatives that might have yielded comparable results with less input.

As project director, I have greatly enjoyed and benefited from what I have learned and experienced through the project. Nonetheless, going into the project I felt that its outcomes for the institution would not match its costs, and the course of the project has only confirmed that perspective. Still, for a larger, more stable institution, this project could have been an excellent choice, and in any case I remain hugely proud of what the Virtual Joust team were able to achieve in spite of the ambient challenges.